Mar 10th, 4:00 PM

Poster Session

Kentucky Water Resources Research Institute, University of Kentucky

GRADING A WATERSHED?

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In an effort to raise awareness of water quality issues and encourage citizens to be active in watershed protection, Kentucky River Watershed Watch (KRWW) has trained and organized volunteer monitors for more than 15 years. The challenge to organizations like KRWW is how to communicate the results over both time and space in a meaningful and easily understandable way to citizens who just want to know *"is something wrong with my stream,"* and *"can I help fix it?"* This project attempts to first assign a letter grade ranging from A to F based on the water quality parameters collected by Kentucky River Watershed Watch; and then use a series of easy to interpret maps to communicate these "grades" to the public. Each parameter is given a grade based on either the regulated standard or proposed limits (when there is not a standard). All of the "grades" for a site are then aggregated into a composite grade for each site. The grades are then mapped using ArcGIS software and converted into KML format viewable using Google Maps to help viewers to see where the overall problems in the watershed exist at a quick glance; and also to view the specific parameters of a given site or set of sites to determine reasons for poor scores. Challenges in assigning individual site scores as well as creating simple but easily interpretable maps will be discussed. The overall goal is to assist citizen water monitoring organizations communicate data more easily and effectively with their volunteers.

NOTES

PERMEABILITY HETEROGENEITY AND ITS EFFECTS ON HYPORHEIC ZONE EXCHANGE

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Permeability heterogeneity significantly influences surface water-groundwater exchange (hyporheic exchange), specifically hyporheic zone extent, exchange rates and water residence times. Hyporheic exchange is an important process that delivers nutrients and solutes needed for time-sensitive chemical reactions to benthic organisms and also controls the fate of contaminants in streambed sediment and watersheds.

Numerical experiments were used to test the role of strongly varying permeability fields (sand-clay units or karst) in controlling hyporheic exchange. We first use a Markov chain approach to simulate three-dimensional (3-D) permeability fields with different ratios of sand and clay and spatial correlation (figure 1). We then include these realizations in fluid flow simulations in an idealized river reach to quantify hyporheic zone extent, fluxes and residence times with differing hydraulic conductivities. Our ultimate goal is to relate sand-clay ratios and connectivity of sand units to residence time distributions.

Preliminary two-dimensional simulations show the strong influence of high-permeability sand bodies and their connectivity (figure 2). Areas of high permeability promote mixing in the hyporheic zone and high permeable sand creates nested flow fields where low permeable clay layers surround it (figure 2). Furthermore, Clay lenses divert flow around them into adjacent sand bodies, where groundwater flows and mixes with ease. Therefore the positioning of these clay lenses greatly affects the hyporheic zone and exchange.

Here, we present initial results from our base case simulation, which shows that sand body geometry has a large impact on exchange. Permeability structure is difficult to measure in streambeds. Improving understanding of the uncertainty that permeability heterogeneity imparts in solute transport will increase our knowledge of surface water-groundwater interactions. Furthermore, the impact of permeability heterogeneity on residence times is very important due to kinetics control of redox-sensitive riparian biogeochemical processes and contaminant degradation. Multi-dimensional computer models can clarify how subsurface heterogeneity impacts solute transport in rivers and their hyporheic zones. Work will include sensitivity analyses to determine uncertainty in exchange behavior and residence times for solute and contaminant transport due to permeability heterogeneity. Our results are broadly applicable to any strongly heterogeneous system, for instance the karst environments that are so abundant in Kentucky.

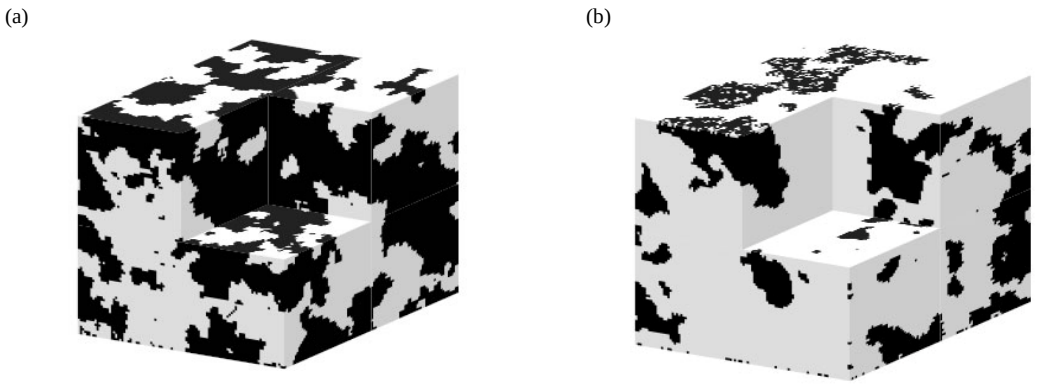

Fig. 1. 3-D geostatistical realization of heterogeneous medium composed of sand and clay: sand-clay ratio is 3:1 in (a) and 1:3 in (b). Realizations were created using a spatial Markov chain approach in the transitional probability software, T-PROGS. Transport in these bimodal permeability fields may also improve our understanding of transport in karst conduit-matrix systems.

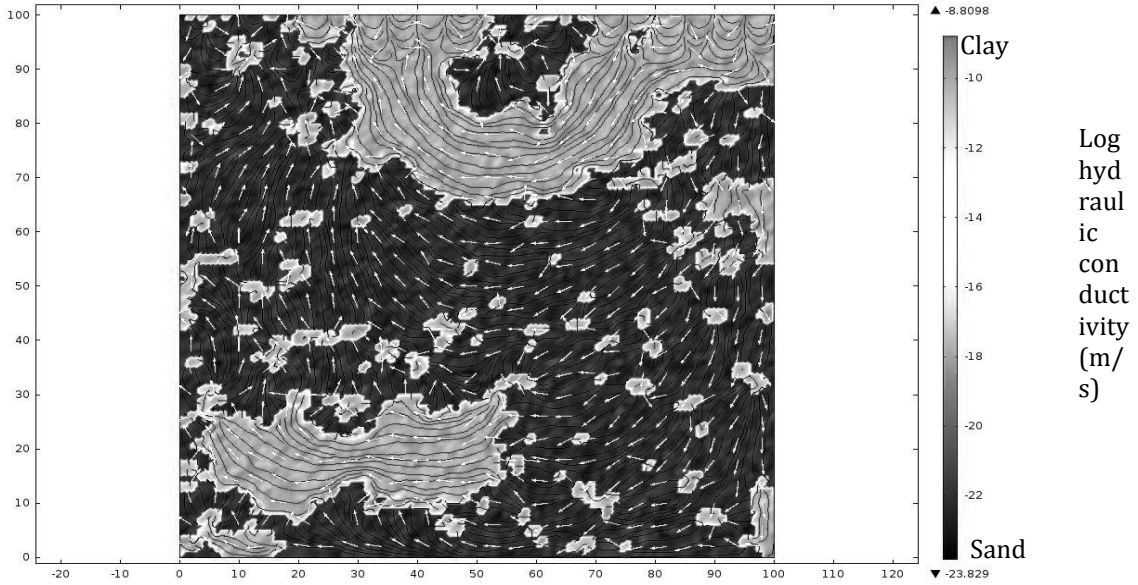

Fig. 2. Preliminary 2-D simulation of hyporheic flow in heterogeneous sediment. The top boundary represents the sediment-water interface of the streambed. A prescribed sinusoidal head along the top boundary imitates flow over bedforms (flow in the stream is right to left). Left, right, and bottom boundaries are no flow boundaries. Connectivity of permeable sand bodies strongly controls flow patterns (black streamlines and white arrows).

EFFECTS OF ATRAZINE ON THE CHEMICAL ALARM CUE RESPONSE IN LONGEAR SUNFISH (LEPOMIS MEGALOTTIS)

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The chemical alarm cue response is a phenomenon in fish whereby prey species exhibit antipredator behavior and predatory species exhibit increased foraging behavior when exposed to fish skin extract. Atrazine is the most widely used herbicide in the United States and one of the most common contaminants found in the ground and surface waters of the U.S. The present study examines the impact of atrazine on chemical alarm cue response in longear sunfish (*Lempomis megalottis*). Fish were collected and acclimated in the laboratory. Fish movement was quantified for 5 minutes prior to and after extract exposure in the presence and absence of atrazine at concentrations of 17, 33, and 50 mg/L. Sunfish exhibited less movement following exposure to extract in the control trials but not in any atrazine trials. This change in behavior following atrazine exposure appears to represent impairment of this predator avoidance mechanism by a widely used herbicide.

NOTES

NEW FEATURES AVAILABLE ON THE KENTUCKY GROUNDWATER DATA REPOSITORY

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Recent improvements have been made to enhance the information available on the Kentucky Groundwater Data Repository. Two of these are the addition of scanned drillers' logs generated through the Kentucky Division of Water's Well Drillers Certification Program and the ability to display locations of available groundwater data on highly detailed digital geologic base maps.

Kentucky law requires that every water-supply or monitoring well in the state be installed by a certified well driller (401 KAR 6:320). Upon completion of each well, certified drillers must submit a detailed log to the Division of Water containing information about the well's location, intended use, depth, and construction. Each driller's log also provides a description of the geologic strata penetrated by the well borehole and, ideally, identifies water-bearing zones and provides limited information about ambient groundwater quality. Since 1985, most, but not all, of the information written on submitted drillers' logs has been manually compiled into electronic data files by the Division of Water and uploaded to the Data Repository by the Kentucky Geological Survey. More recently, drillers have had the option of submitting logs electronically. In July 2013, nearly 300,000 scanned digital images of original drillers' logs and associated documents were provided by the Division of Water to the Survey, and were processed and placed online in October. One major benefit of this capability is that all information visible on the original drillers' logs, including hand-written notes or drawings, can now be reviewed and used as desired, including descriptions of geologic strata and depths of encountered water-bearing zones.

Kentucky is one of only two states in the nation with complete digital geologic map coverage at a scale of 1:24,000. Users of the Data Repository are now able to interactively access high-resolution geologic base maps for displaying the locations of well construction, spring, and groundwater-quality data retrieved from the Data Repository. Clicking on any geologic unit on the search results map will bring up detailed geologic information on the selected unit. Also available is an option to view the original U.S. Geological Survey 7.5-minute geologic quadrangle map lithologic descriptions for the unit. This feature allows access to detailed geologic data from anywhere in the state.

The addition of drillers' logs and digital geologic base maps to the Data Repository has already proven beneficial, both to the general public and to drillers themselves, in searching for new groundwater supplies. To access the Data Repository, go to www.uky.edu/kgs and click on "data," then on "groundwater."

REMOVAL OF PERSISTENT ORGANIC POLLUTANTS FROM CONTAMINATED WATER SOURCES UTILIZING POLYPHENOL-FUNCTIONALIZED MAGNETIC NANOCOMPOSITE MICROPARTICLES

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Magnetic nanocomposite microparticles (MNMs) were produced using iron oxide nanoparticles incorporated into a polyphenolic-based polymer matrix with high affinity for organic pollutants. This platform allows for the specific binding of chlorinated organics from contaminated drinking water sources, the rapid magnetic separation of bound organics, and the thermal destabilization of the polymer matrix for contaminant release and material regeneration. This platform is of special interest for addressing both contamination at U.S. Superfund sites as well as in developing nations where levels of chlorinated organic pollutants are increasing at an alarming rate in conjunction with increasing industrialization. Quercetin multiacrylate (QMA) and curcumin diacrylate (CDA), acrylated forms of these widely used nutrient polyphenols, with known affinity for chlorinated organics, were crosslinked with polyethylene glycol (PEG) diacrylate using a free radical polymerization in the presence of magnetic iron nanoparticles, and the magnetic nanocomposite was subsequently cryomilled to form the MNMs. Particles were characterized using transmission electron microscopy (TEM), dynamic light scattering (DLS), Fourier transform infrared spectroscopy (FTIR), and thermal gravimetric analysis (TGA). Pollutant binding studies were performed using model chlorinated organic pollutants, polychlorinated biphenyls (PCBs, specifically PCB 126), to determine binding affinity and capacity, as well as optimal binding kinetics, and this was quantified using LC-MS/MS. It was demonstrated that the MNMs effectively bound PCBs with the addition of QMA or CDA resulting in a near two-fold or four-fold increase in affinity, respectively. An alternating magnetic field (AMF) was used to heat and destabilize the binding in the polymer matrix leading to PCB release from the particles, and the percentage of uptake and release were determined. Repeated PCB binding/release was performed to determine MNM stability and reusability. This work provides a rapid, non-toxic platform for pollutant removal from contaminated water sources both near Superfund sites throughout the U.S. and in developing nations. (Supported in part by grants from NIEHS, NIH (P42ES007380) and UK AES)

NOTES

DYNAMIC SURFACE WATER-GROUNDWATER INTERACTIONS IN A TIDALLY INFLUENCED RIVER (CHRISTINA RIVER BASIN CRITICAL ZONE OBSERVATORY, DELAWARE, USA)

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Tides drive dynamic river-groundwater exchange in coastal rivers. Surface water infiltrates bank storage zones on the rising tide, and groundwater returns to the channel on the falling tide. The timing of maximum groundwater discharge with respect to river discharge can impact export of nutrients and contaminants from watersheds to oceans. Periods of high bank storage and nutrient uptake may be coupled to low stream discharge, creating periods of rapid nitrate removal. Since tides extend for tens of kilometers inland from the coast, tidal surface water-groundwater exchange may increase nitrogen uptake in coastal rivers.

We investigated the effect of tidal fluctuations on surface water-groundwater in White Clay Creek, located in the Cristina River Basin (Delaware, USA), one of six NSF-funded critical zone observatories. Rates of surface water-groundwater exchange across the banks were estimated by monitoring water table fluctuations in shallow wells in the riparian aquifer. River discharge and velocity were recorded with an acoustic doppler current profiler. Water samples were also collected from both the groundwater and surface water over one tidal period and analyzed for nitrate and chloride.

Preliminary results show that at low tide, groundwater recharges the stream. At high tide, the hydraulic gradient reverses and river water recharges the aquifer (Figure 1). The tidal bank storage effect may influence nutrient cycling and contaminant attenuation. Nitrate is elevated in groundwater relative to surface water. Bank storage can increase residence times and thus the extent of nitrate uptake in groundwater. Future studies will characterize how nutrient cycling is influenced in the riparian zone of White Clay Creek. A better understanding of surface water-groundwater exchange and nutrient cycling in tidally influenced rivers can inform management decisions for coastal watersheds. For example, the Kentucky River is part of the Mississippi River watershed. Nitrogen uptake in tidally influenced portions of the Mississippi River watershed may reduce nitrogen loads from inner states like Kentucky to the coast.

Figure 1:

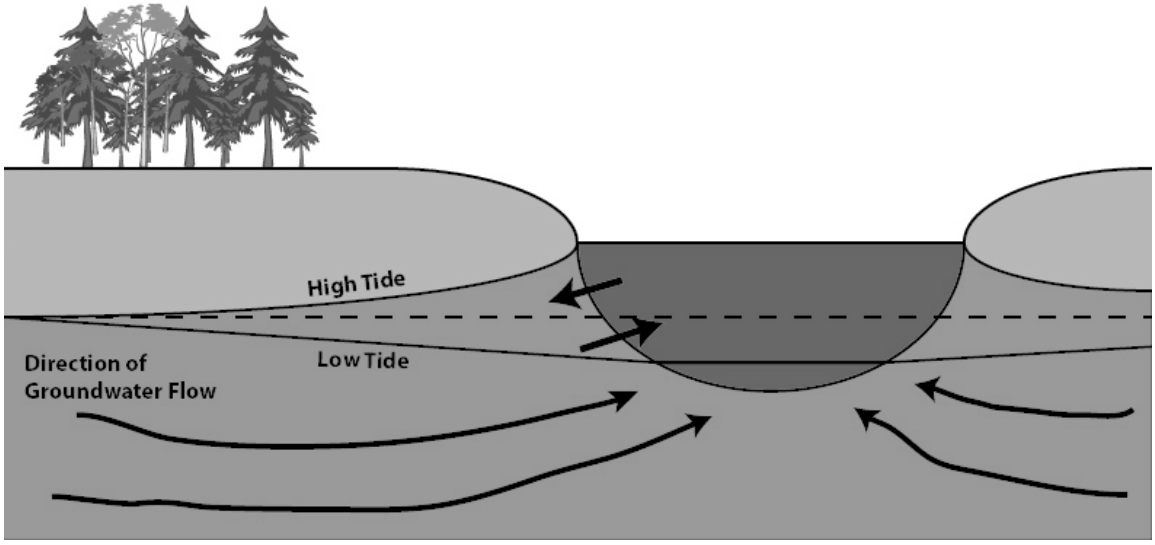

Figure 1: Tidal variations in stream stage cause reversals in groundwater flow across banks. These flow reversals provides opportunity for nitrate attenuation within the banks. The timing of surface water-groundwater exchange with regard to downstream transport may play an important role in controlling nitrogen fluxes to coasts.

SEDIMENT-WATER PHOSHORUS INTERACTIONS IN MINOR CLARK FISH HATCHERY POND SEDIMENTS

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The Minor E. Clark Fish Hatchery near Cave Run Lake is operated by the Kentucky Department of Fish and Wildlife Resources. This state fish hatchery is one of the largest warm-water fish hatcheries in the nation. The interaction between hatchery pond sediments and overlying pond water has implications for fisheries management. Hatchery ponds are generally fertilized with organic and inorganic fertilizer to increase plankton growth. Despite this fertilization, Minor Clark Fish Hatchery pond sediments may provide additional nutrients to the water column. Extractable P concentrations in five ponds decreased from 36 mg/kg to 14 mg/kg between 2008 and 2013. If Minor Clark earthen pond sediments are a source of nutrients when rearing fish, it has management implications for hatchery ponds constructed and restored using plastic liners. Soil P isopleths from 2008 suggested sediments released about 5 µg P/g sediment/d. These sediment isopleths were obtained using solution soluble reactive P (SRP) concentrations normally found in pond water during fish rearing (<70 µg/L). Subsequent comparisons of pond primary production, and fish growth and survival, suggests that plastic-lined ponds are more fertile and productive than earthen ponds. We took sediment samples from six 1-acre and eight 0.1-acre ponds to determine their initial sediment nutrient concentrations and textural composition. We then assessed the interaction between sediments and available P with isotherms at higher concentration than used in our 2008 analysis. One-gram of sediment was mixed with 25-ml of solution containing Cave Run

Lake water spiked with SRP to final concentrations of 8 (no addition), 96, 160, and 1,500 µg-P/L. The slurry was mixed in 50-ml round-bottomed centrifuge tubes with an under-over spinner, at the rate of about 6 rpm, for 24 hours. Sediments incubated with non-supplemented Cave Run Lake water (8 µg/L concentration) released P to the solution at an average rate of 0.5 µg P/g/d. We found P was adsorbed by sediments at all other concentrations; with the highest adsorption occurring with the highest loading (1,500 µg-P/L adsorbed an average of 36 µg P/g/d). These results suggest that pond sediments may not be as important to hatchery pond plankton growth as previously suspected.

THE ROCHESTER VALLEY CHANNEL SANDSTONE AQUIFER: A POTENTIAL SOURCE OF GROUNDWATER IN THE WESTERN KENTUCKY COAL FIELD

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Increased water demands, recent drought, and the costs of using surface water have caused municipalities, industries, and agricultural producers located in the Western Kentucky Coal Field region to assess the possibility of using groundwater as their primary or supplemental water source. This change in thinking is significant because available data indicates that most bedrock aquifers in the region cannot yield the volume of water required to sustain even low-capacity municipal or industrial wells. However, some Pennsylvanian channel sandstone units, such as the Rochester valley aquifer (in the base of the Caseyville Formation), may be productive sources of groundwater. As mapped by Davis and others (1974), the Rochester aquifer underlies an area of more than 250 mi^2 in portions of four counties (Muhlenberg, Ohio, Butler, and Edmonson) and ranges in depth from less than 100 to more than 900 ft below ground surface. Unlike other deep, confined, channel sandstone aquifers, such as the Greenville valley aquifer, the Rochester aquifer is believed to have a recharge zone near Reedyville, Kentucky. Recharge to the aquifer would increase long-term sustainability of the aquifer and improve its potential as a reliable source of water over time. However, our present understanding of the hydrogeologic properties of the Rochester valley aquifer, and its potential as a source of groundwater to higher-yield water supply wells is severely limited by lack of quantitative data. Water-level data needed to map the water-table or potentiometric surface elevation, and hydraulic data such as transmissivity and storage coefficients, are not available for the Rochester valley aquifer. Groundwater-quality data are available for only two water wells known to be drilled into the aquifer. A more comprehensive hydrogeological investigation of the Rochester aquifer would be beneficial to assess its potential as a reliable source of groundwater for high-yield water supply wells.

Davis, R.W, Plebuch, R.O., and Whitman, H.M., 1974, Hydrology and geology of deep sandstone aquifers of Pennsylvanian age in part of the Western Coal Field Region, Kentucky: Kentucky Geological Survey, ser. 10, Report of Investigations 15, 26 p.

NOTES

PARTIAL DESALINATION AND SELENIUM REDUCTION FOR ENERGY APPLICATIONS

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Water intensive processes in the energy industry such as wet flue gas desulfurization and hydraulic fracturing are becoming more prevalent. Partial desalination and selenium reduction utilizing membranes offer a low energy treatment method in which process water can be recycled without the danger of accumulation of unwanted TDS and Se in the system. Reduced water consumption and waste disposal costs allow for affordable and regulation-compliant operation in the energy industry.

Nanofiltration (NF) membranes offer a solution for reducing dissolved solids in process water. Often, drinking quality water is not required for industrial processes. Charged NF membranes allow for high rejection of divalent ions (Ca^{2+}) while allowing monovalent ions (Na^{+}) to permeate through. As charged NF membranes allow certain ions to permeate through, they are able to achieve a high flux with much less pressure than reverse osmosis membranes. NF membranes are available commercially (Dow NF-270 is a common example). Two Sepro NF membranes, one positively charged and one negatively charged have been tested extensively. Large-scale results were obtained for both membranes using 6.4 ft^2 spiral wound membrane modules.

Both positive and negative membranes have been shown to effectively reject divalent ions. Flue gas desulfurization water with a TDS concentration of 11,000 ppm (3000 ppm Ca^{2+}, 700 ppm Mg^{2+}, 75 ppm Na^{+}, 5873 Cl^{-}, 1124 SO_4^{2-}) from a power plant was tested in this experiment. Utilizing ICP-OES it was determined that the positively charged membrane rejected 83.8% Ca^{2+}, 93% Mg^{2+}, 5% Na^{+}, and 77.1% of overall TDS while maintaining a water flux of 32.2 LMH at an operating pressure of 13.45 bar. It was determined that the negatively charged membrane rejected 97.2% Ca^{2+}, 98.6% Mg^{2+}, 21% Na^{+} and 92.7% of overall TDS while maintaining a water flux of 33.2 LMH. The operating temperature was held at 25 °C. The TDS rejection is lower than the Ca^{2+} and Mg^{2+} rejections because monovalent ions were able to pass through NF membranes. Total ion charge was balanced between feed and permeate (counter-ions are also rejected). Overall, both NF membranes show great promise in rejecting divalent cations and anions from process water (water softening/Ca^{2+} removal), while allowing a higher water permeability than RO membranes.

While Selenium (Se) is an essential element in human and animal nutrition, it can be hazardous at larger concentrations. In recent years, the control of Se release to the environment from mining, manufacturing wastewater and agriculture drainage has attracted more attention. The EPA has decreased the MCLG of Se to 50 ppb. The development of nanomaterials allows us to make highly reactive catalysts such as iron/iron oxide nanoparticles (NPs) for Se remediation in water. By incorporating those particles into the polymer (such as polyacrylic acid, PAA) functionalized polyvinylene fluoride (PVDF) membrane pores, the particle agglomeration and leaching was eliminated. With only deionized (DI) water, the batch reaction between iron and selenate completed fast, and maintained high reactivity for five cycles. Selenate concentration decreased to as low as 5 μg/L (ppb). Depending on the iron loading, selenate could be removed within a short residence (contact) time (e.g. 91.4% conversion in 6 s with 4 mg of iron immobilized in an area of 13.2 cm^2) when passing through the membrane (convective flow).

The dissolved salt in water did affect the reactivity of iron. The anions like chloride and sulfate will be adsorbed on the iron surface, competing with selenate. To eliminate the interference of salts, the scrubber water sample was first passed through the nanofiltration (NF) module, and the permeate (with less salt) used as the feed to iron functionalized membranes. The NF module removed more than 90% of selenate. Selenate could be further reduced to ppb level (below 5 μg/L) with 77% conversion on average by iron functionalized membranes. X-ray photoelectron spectroscopy (XPS) shows that selenate was mainly reduced to selenium (Se^0) with some adsorbed on the iron surface (iron oxide shell). The successful loading of iron NPs (0.65 g) in the membrane module (5 ft^2 PVDF) indicates the potential application of this membrane platform for large-scale selenium removal.

The TDS rejection aspects of this research are funded by Southern Company of Birmingham, AL. Funding for the Fe functionalized membrane research was provided by NIEHS-SRP We acknowledge the significant contributions of Sepro Membrane Inc. of Oceanside, CA towards the joint development of full-scale PVDF functionalized membranes.

USE OF PERACETIC ACID (PAA) AS A DISINFECTANT FOR WASTEWATER AND WASTEWATER OVERFLOWS: AN EVALUATION OF PAA SUPPLIER PERFORMANCE

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There are at least three manufacturers in the United States that offer either 12% or 15% solutions of Peracetic Acid appropriate for the disinfection of wastewater and wastewater overflows. Each manufacturer claims that their product offers superior performance which would result in proprietary disinfection designs and require the sole source supply of Peracetic Acid, giving the user little flexibility to choose between competing products. A study has been conducted at the University of Kentucky to determine the accuracy of this claim. The results indicate that the performance of these products is equal allowing users to determine the required dosage concentration of Peracetic Acid and the system design as opposed to the supplier making these determinations. This gives the user independence regarding their designs and the selection of which product they use in their disinfection systems.

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WATER DISTRIBUTION SYSTEM MODELS FOR SMALL WATER UTILITIES

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Mathematical models of water distribution systems have been shown to be very useful in the management and operation of water distribution systems. However, many small water utilities do not have the personnel or fiscal resources to build and maintain water distribution models for their systems. Working with a commercial partner (KYPIPE), the Kentucky Water Resources Research Institute has developed three different computer models specifically designed to address the needs of small water utilities. These models include 1) a graphical flow model, 2) a sensor placement model, and 3) a pipe break/contamination isolation model. Each model has been developed for use with the Kentucky Infrastructure Authority online GIS database to facilitate construction of these models for any system in Kentucky. Further, the models can be downloaded for free, for systems less than 1000 pipes at http://kypipe.com/decon

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FLOYDS FORK WATERSHED STAKEHOLDER ENGAGEMENT PROJECT

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The Floyds Fork drainage lies within the Outer Bluegrass physiographic region in Jefferson, Oldham, Henry, Shelby, and Spencer Counties, and enters the Knobs Subsection of the Bluegrass in Bullitt County. Floyds Fork drains an area of 284 square miles, flowing a length of 62 miles. It begins in Henry Country near Smithfield, flows through eastern Jefferson County and into the Salt River near Shepherdsville.

In 2011, the Kentucky Water Resources Research Institute was asked by the Kentucky Division of Water to work with stakeholders in the Floyds Fork Watershed to identify concerns and preferences with regard to nutrient management BMPs for the watershed. In response, the KWRRI developed and implemented a five step engagement methodology that involved 1) stakeholder identification, 2) initial interviews, 3) focus group meetings, 4) public information meetings, and 5) public scoring meetings. Ultimately, 20 separate BMPs were identified and then scored as part of the process. This poster will summarize the challenges associated with the process and provide a summary of the results.

Additional information related to the Floyds Fork Stakeholder Engagement Project can be found at:

http://www.uky.edu/WaterResources/FF/

NOTES

NUTRIENT LOAD ESTIMATION USING NSPECT MODEL FOR SALT CREEK, INDIANA

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Water quality is impacted severely during rainy days through non point source pollution. Non point source pollution is very difficult to handle, but can be controlled by best management practices. To plan such best management practices, watershed level water quality estimation is necessary. In this study, a NOAA tool called NSPECT Model was used to generate a raster database for Salt Creek located in northwest Indiana. NSPECT stands for Nonpoint Source Pollution and Erosion Comparison Tool. This tool is an add-on to ARC GIS software. The recent version of this software is available with MAP WINDOW platform which is public domain software. This user friendly tool is used for estimating nutrient loads from Salt Creek.

Salt Creek watershed located in Northwest Indiana's historic Indiana Dunes region is considered for this study. This creek drains part of Porter County to the Little Calumet River East Arm, which in turn drains to Lake Michigan through Burns Ditch. This watershed includes urban pockets such as Valparaiso and Hobart. Save the Dunes agency implements several watershed management best practices in this region. This 24 mile long creek drains 77.46 square miles (Fig 1).

Region

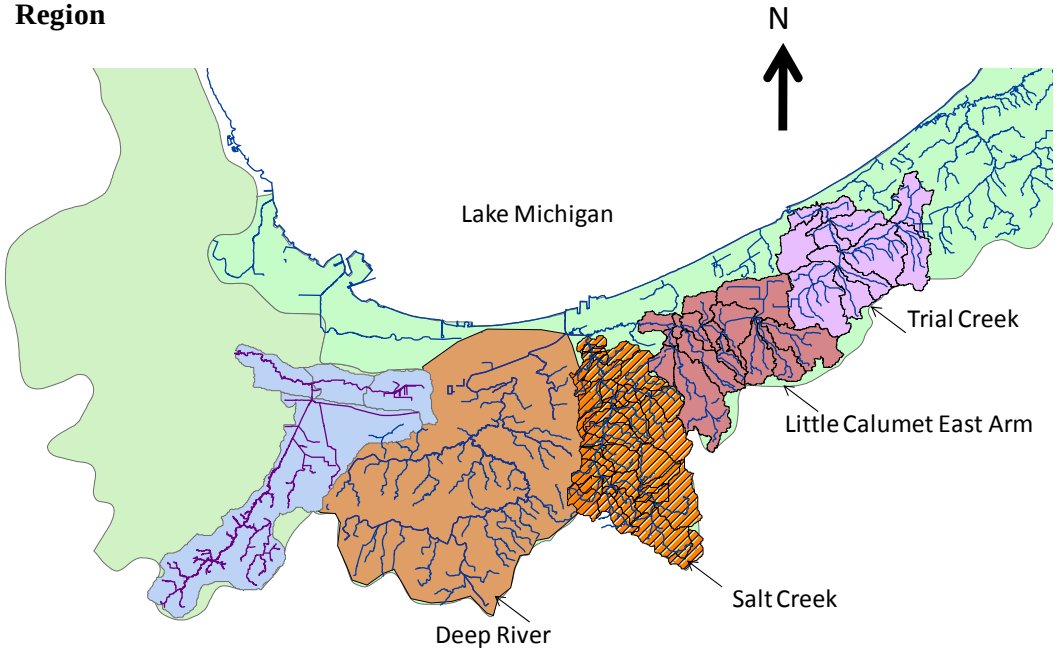

Figure 1. Salt Creek Watershed Location in Northwest Indiana

Spatial data were used for developing the nutrient load estimation. Both vector and raster datasets were required for this purpose. Digital Elevation Model (DEM), Precipitation Raster file for the considered month, soil characteristics (hydrology group), and landuse details were used as input datasets. The NSPECT model uses a coefficient based approach to derive the loads emerging from different locations and estimates the flow volume and the nutrient load for the entire watershed. This algorithm uses an SCS curve number approach to estimate the runoff volume (N-SPECT Technical Guide 2004). The NSPECT model works well with the MAPWINDOW platform with which preliminary geoprocessing steps were done in this study. All the input files are downloadable from different agencies and they were geoprocessed initially using ARC GIS or MAPWINDOW. This tool also facilitates user comparison of changes in loading pattern due to changes in landuse. Calibration of the nutrient load was done using historic observations.

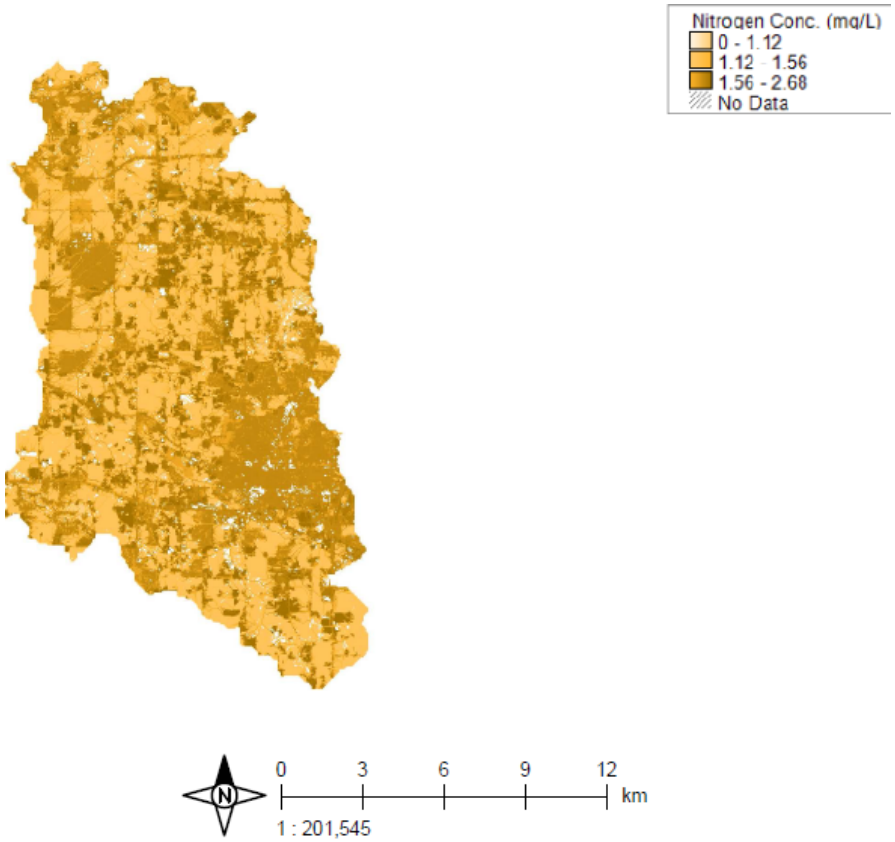

Figure 2. Nutrient Load Estimated using NSPECT Model

Acknowledgement: Authors thank Indiana DNR Coastal Grant support for conducting this study. **Reference:** NOAA Publication, 2004, Nonpoint Source Pollution and Erosion Comparison Tool Technical Guide, Version1.0, November 2004.

ANALYZING PRECIPITATION BASED CLIMATE INDICES FOR MICHIGAN

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Precipitation based climate indices are used to study the changing behaviors in precipitation patterns in the past (Chandramouli *et al.* 2012). These simple indices are easy to estimate and can provide regional changes in temporal and spatial domains (Teegavarapu *et. al.*, 2012a). A preliminary analysis for Michigan is presented in this study. Six indices: 1) maximum one day precipitation, 2) maximum 5 day precipitation, 3) number of rainy days recorded with more than 10 mm rainfall, 4) number of rainy days recorded with more than 20 mm rainfall, 5) number of consecutive dry days, and 6) number of consecutive wet days were examined using 60 years of historic rainfall stations. Figure 1 shows the stations considered for this analysis. Daily precipitation data for these stations were downloaded from the National Oceanic Atmospheric Agency (NOAA) site.

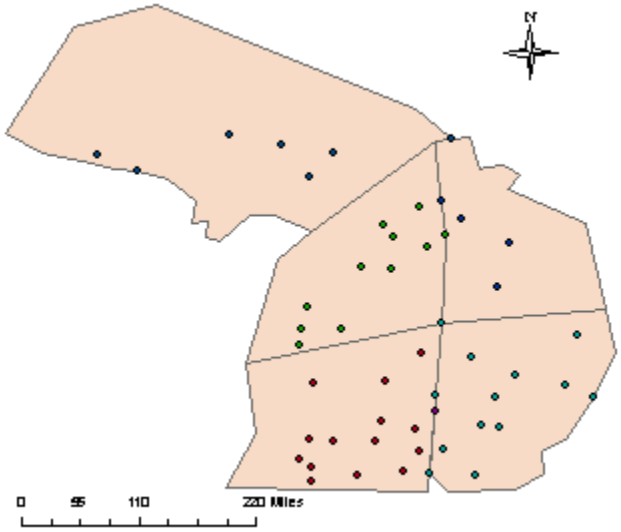

Figure 1. Rainfall Stations considered in Michigan

For this analysis, Michigan was subdivided into Northeast, Northwest, Southeast, Southwest and Upper Peninsula regions. For each region, the daily precipitation data were grouped into two 30 year domains (1950 to 1980, 1981 to 2010) and the precipitation-based climate indices were examined for each domain in each region. Missing data in each region were filled in using an arithmetic average method. Each precipitation-based climate index was calculated using a spreadsheet and the results were used for geospatial database creation using ARC GIS software. Construction of raster maps was done using a kriging spatial interpolation algorithm in an ARC GIS platform for each index and the changes were examined using the raster files created.

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TAKING RUNOFF BY STORM: STORMWATER YOUTH EDUCATION

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The Environmental and Natural Resource Issues Task Force, together with host county Extension agents through a collaboration between the Master Gardener Program and the Tracy Farmer Institute for Sustainability and the Environment, developed a workshop to help homeowners and communities implement residential best management practices. During the development and implementation of these materials and workshops, several 4-H Youth Development (4-HYD) Extension agents expressed interest in presenting rain garden information to youth. As a result, lessons were created about rain gardens for agents to use with youth. Each lesson includes background information about the subject matter and hands-on activities. The lessons focus on issues related to water quality, soils, plants, and phenology in relation to rain gardens. In-service trainings, including classroom and hands-on instruction, were offered to 4-HYD agents at each of the four Kentucky 4-H Camp Facilities. At each in-service training, agents were given an opportunity to do activities from the lessons, and also install a rain garden at the 4-H camping facility. These provided a great opportunity to get agent feedback on the lessons, and also establish a rain garden at each camp to be used by agents and youth at future programs (e.g., environmental camp, summer camp, etc.). In addition, seven county programs have also been implemented involving 4-HYD agents, teachers, and youth. At each of these programs, adult leaders and youth participated in activities from the lessons and took an active role in installing the gardens. Currently, the lessons are still in pilot phase but will be available online when finalized.

NOTES